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V. V. Mikhnevich and V. A. Sokolov

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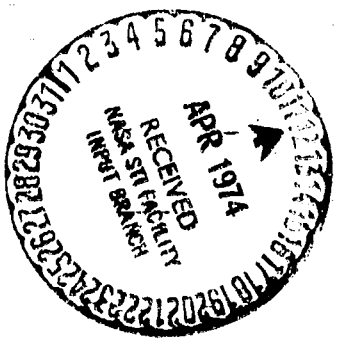

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Thermodynamic Characteristics of the Lower Atmosphere of Venus According to the Results of Experiments by the Descent Module AMS† of Venera-4

V. V. Mikhnevich and V. A. Sokolov

The thermodynamic characteristics of the lower atmosphere of /251* Venus on the night side in the neighborhood of the morning terminator were determined on October 18, 1967 as a result of direct measurements by the descent module of Venera-4.

The measurement of the temperature was performed during the entire period of the experiment of the descent module; measurements of density and pressure, before off-scale reading of the devices [1]. A determination of the module's altitude above the surface of the planet was made at one point. The chemical structure was determined at two levels at the beginning of the smooth landing [2].

The temperature was measured in the range 304-544° K and density in the range $1.4 \cdot 10^{-3}$ to $1.2 \cdot 10^{-2}$ g/cm^3. In Figs. 1 and 2 the results of measurements of density and temperature are depicted. The root-mean-square error in the density determination was $\pm 0.18 \cdot 10^{-3}$ g/cm^3 at the beginning, and $\pm 3 \cdot 10^{-3}$ g/cm^3 at the end of the measurements, and the error in the temperature measurement was ±4°.

An extrapolation of the density up to the moment corresponding to the last measurement of the temperature was conducted because of the absence of data on density in the final cycle of operation of the descent module. The extrapolation was generated by various methods: according to a "density-time", "entropy-pressure", "density$^{-1/2}$·temperature$^{-1/2}$-time" graph; according to a polytrope by means of a matching of the path traversed obtained from the equation of motion of the descent module and from the hydrostatic equilibrium equation.

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* Numbers in the margin indicate pagination in the foreign text.

† Robot space station

The results of the extrapolation with all the methods conform quite well with each other and lie within the range $16.9 \cdot 10^{-3}$ to $17.9 \cdot 10^{-3}$ g/cm^3 (Fig. 3) for the moment at the end of the measurement of the temperature.

The distribution of density and temperature obtained permitted the path traversed to be determined. A barometric formula and motion equation was used for this. The path traversed was also determined from the condition of an adiabatic atmosphere.

An examination of the preliminary results of the upper atmosphere distribution of pressure and temperature showed that in the range of altitudes from 10 to 25 km a nonmonotonic variation of density and pressure was observed, calculated according to the equation of state for temperature and density, assuming that the atmosphere consists of carbon dioxide gas at all altitudes.

Connected with the fact that in the upper atmosphere distribution of density, obtained in the barometric formula using only the temperature data, analogous behavior was not observed in the further calculations, a smoothing variation of density was assumed (Fig. 3). A discussion of some possible reasons for the increase in the readings of the densimeter in the region shown was presented in [3].

Although the discrepancy of the path traversed, determined by the methods explained above, was small, nevertheless the upper atmosphere distribution of the thermodynamic properties, and, in the given case, a conclusion on the stability of the atmosphere, depends on the choice of path traversed.

The analysis of the state of the gas presented according to the measured values of density and temperature, irrespective of their upper atmospheric distribution, taking into account the errors in the measurements, only permits us to assert that, in the region considered, the atmosphere of Venus is found in a state approaching adiabatic conditions. In this case it is entirely

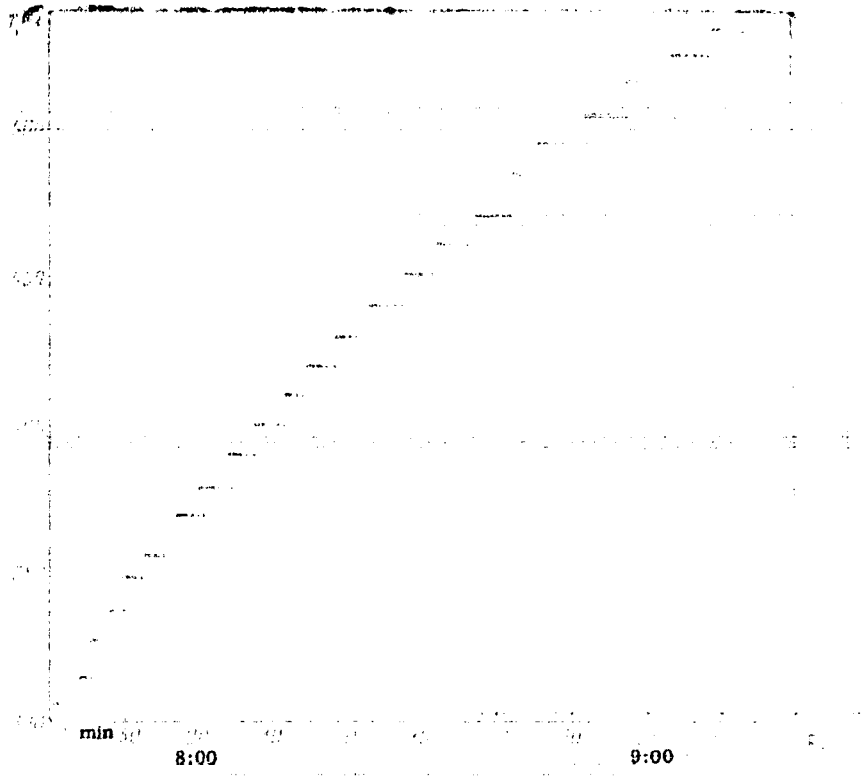

Figure 1. Temperature. Solid lines show the range of time within which the measureable value corresponds with a fixed level of temperature.

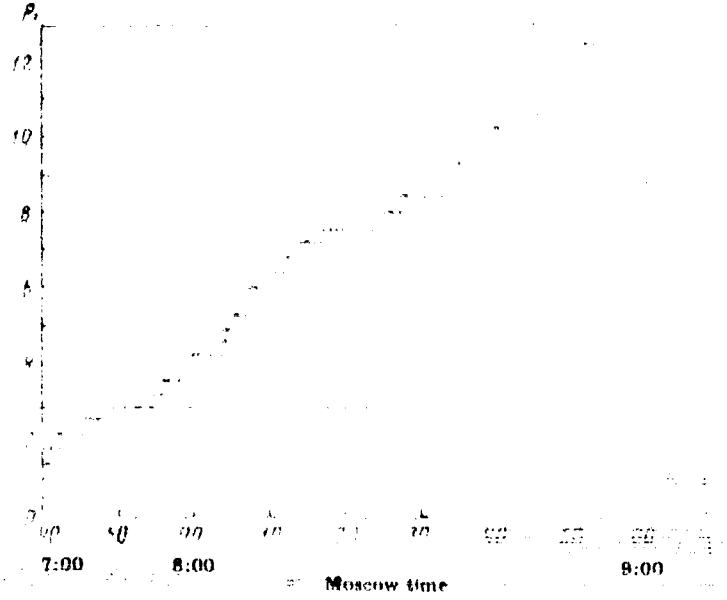

Figure 2. Measurements of density as a function of time (density given in 10^{-3} g/cm^3).

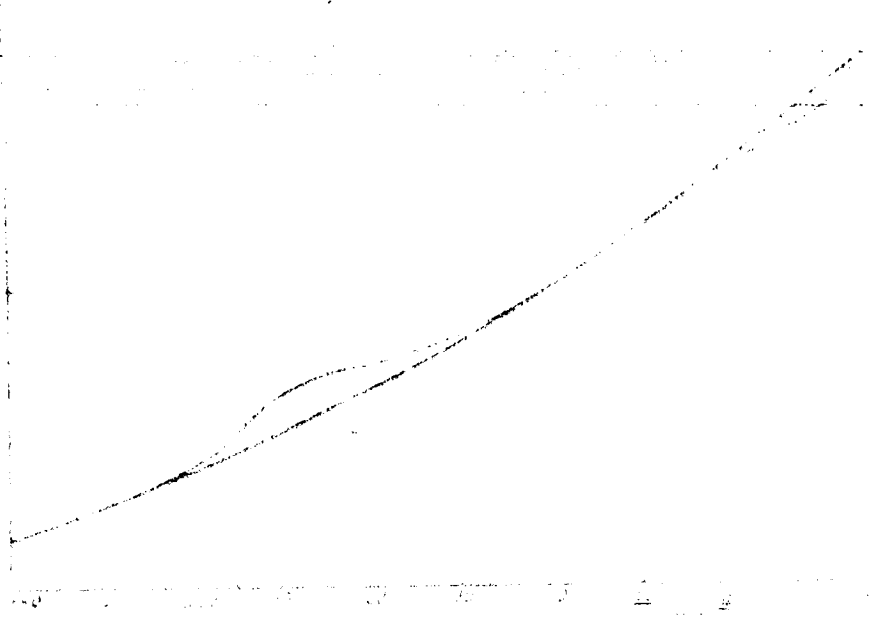

Figure 3. Density of atmosphere (in 10^{-3} g/cm^3). 1- the curve is traced along measured points; 2- smoothed curve; 3- a segment of the extrapolation.

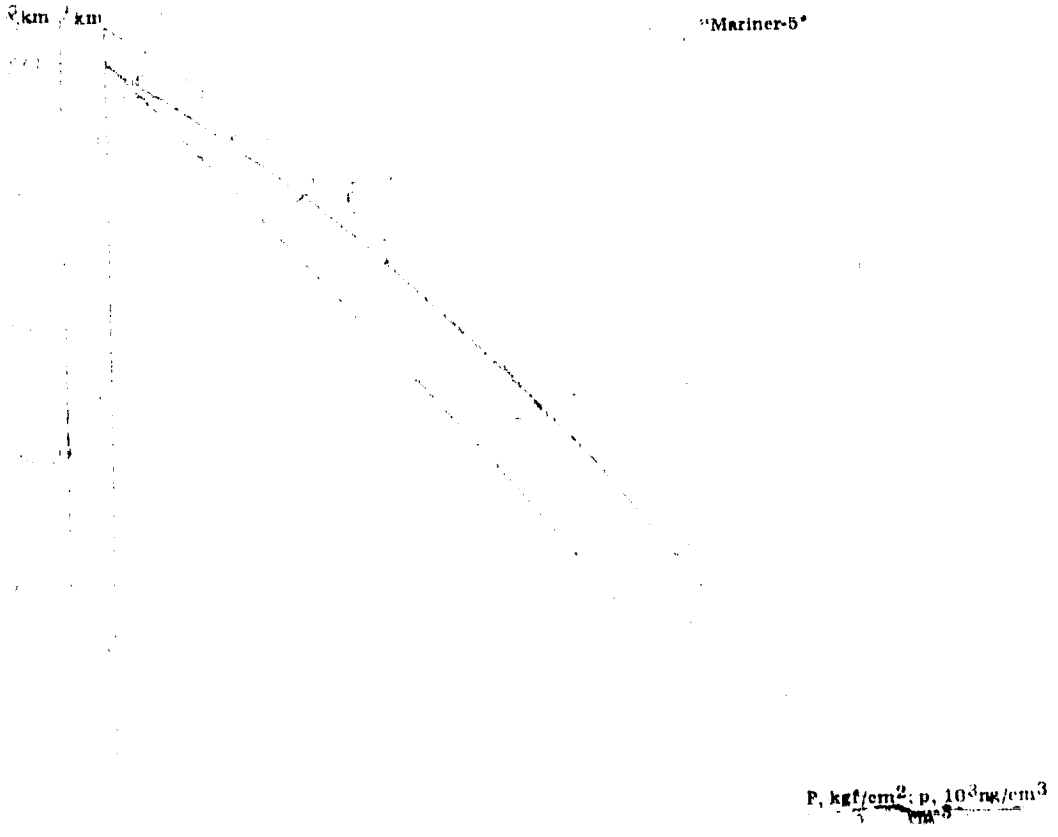

Figure 4. Temperature, density, pressure, and abundance of the lower atmosphere of Venus.

permissible to accept the upper atmosphere distribution of parameters corresponding with the condition of adiabatic distribution.

In Fig. 4 the upper atmosphere distribution of pressure P, density ρ, temperature T, and abundance N of atmosphere is depicted. These data characterize the l .t state of the atmosphere in the neighborhood of the equator o.. the night side during the measurements of October 18, 1967. /254

In the table of the values corresponding to the values of the parameters of Fig. 4, the values of the thermodynamic parameters of the atmosphere at relative altitudes are given; the altitude corresponding to the conclusion of the measurements on the descent module of Venera-4 is assumed to be "zero".

km	kG/cm^2	g/cm^3	cm^{-2}	km	kG/cm^2	g/cm^3	cm^{-2}

As a result of the experiment on Venera-4 it was established that if by chance the composition of the gas at all altitudes is the same, then the conditions in the lower atmosphere approach adiabatic, and it is likely that the state is nonstable. The values obtained of pressure, density, and temperature at the conclusion of the descent were not less than the values 18.4 kG/cm^2, $18 \cdot 10^{-3}$ g/cm^3, and 544° K, respectively.

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16. Abstract

The article summarizes results of experiments made aboard the descent module of Venera-4 concerning the thermodynamic characteristics of the lower atmosphere of Venus. Results presented include measurements of temperature, density, and pressure according to altitude above the planet.

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